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# INDUSTRIAL WASTEWATER TREATMENT USING MORINGA SEED

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## ABSTRACT

*Moringa oleifera is a multipurpose tree with considerable potential and its cultivation is currently being actively promoted in many developing countries. Seeds of this tropical tree contain water soluble, positively charged proteins that act as an effective coagulant for water and wastewater treatment. Based on this, wastewater from a soap making factory was analyzed before and after the treatment using activated carbon processed from moringa seed. However, the parameters were reduced after treatment from 20.10 ± 0.039 to 0.99±0.009mg/L in copper (Cu) and 15.61 ± 0.055 to 1.23 ± 0.005 mg/L in iron (Fe) respectively. Nevertheless, there was no significant alteration of pH conductivity. Cu and Fe were successfully removed. Overall, 15g of activated carbon processed from moringa seed was enough to remove heavy metal from wastewater sample. This preliminary laboratory result confirms the great potential of activated carbon processed from moringa seed in wastewater treatment applications*

**KEYWORDS:** Wastewater, Treatment, Activated Carbon, Processed, Moringa oliefera



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## INTRODUCTION

Wastewater refers to any water that has been used and discharged due to various human activities encompassing domestic, industrial, agricultural, and commercial practices. It typically comprises an array of pollutants, such as organic and inorganic substances, pathogens, nutrients, and suspended solids. Domestic wastewater, also termed as sewage, is primarily generated from households, encompassing water from toilets, showers, sinks, and other similar sources. It often comprises high levels of organic matter, nitrogen, and phosphorus, as well as pathogenic microorganisms like bacteria and viruses.

Industrial wastewater, is derived from diverse manufacturing processes and can contain various pollutants, such as heavy metals, organic chemicals, and other toxic substances. The composition of industrial wastewater can vary significantly based on the type of industry and its specific processes. Meanwhile, agricultural wastewater is generated from farming activities like irrigation, animal husbandry, and crop harvesting, and can comprise elevated levels of nutrients like nitrogen and phosphorus, as well as pesticides and other agricultural chemicals.

Furthermore, commercial wastewater arises from commercial activities, such as restaurants, hotels, and car washes, and typically contains significant quantities of fats, oils, and grease, along with cleaning chemicals and other contaminants. Despite the origin, wastewater necessitates treatment to eliminate contaminants and ensure that it conforms to regulatory standards before it is discharged into the environment or reused.

The wastewater treatment process usually involves multiple stages, including primary treatment to remove solids, secondary treatment to eliminate organic matter, and tertiary treatment to eliminate nutrients and other pollutants. Additionally, advanced treatment technologies may be employed to eradicate emerging contaminants like pharmaceuticals and personal care products from wastewater.

Copper is a ubiquitous heavy metal that is present in natural water sources, and its accumulation in water bodies is a major environmental concern due to its toxicity and potential health risks to humans and wildlife. Copper contamination of water can occur through both natural and anthropogenic sources, such as mining, industrial activities, and agricultural practices (Liu et al., 2019). Copper can also leach into water from plumbing systems, particularly in older buildings with copper pipes (Siddique et al., 2021).

Copper is an essential nutrient for living organisms, but excess copper can cause adverse effects on human health, including liver and kidney damage, anemia, and gastrointestinal disorders (Gupta et al., 2014). Copper can also accumulate in aquatic ecosystems, leading to toxic effects on aquatic organisms, including reduced growth, reproductive failure, and mortality (Zhu et al., 2019).

Iron contamination in water can have various sources, including natural processes and human activities. Iron can naturally dissolve in water from soil and rock formations, and can also seep into surface water from groundwater sources. Anthropogenic activities such as mining, industrial discharge, and sewage treatment can also contribute to iron contamination in water. The release of iron and other heavy metals into water sources through leaching or runoff from mining activities, and through discharge from industrial activities such as steel production and chemical manufacturing, are some examples of anthropogenic sources of iron contamination in water (Lu et al., 2018).

Iron contamination in water can have negative effects on human health and the environment. High levels of iron in drinking water can cause aesthetic problems such as discoloration and staining of household fixtures, as well as a metallic taste (Siddique et al., 2021). Exposure to high concentrations of iron in drinking water has also been associated with adverse health effects such as gastrointestinal distress, liver and kidney damage, and developmental delays in children (Bolton, 2017). In addition, iron contamination in water can promote the growth of certain algae and bacteria, leading to oxygen depletion and harm to aquatic life (Liu et al., 2019). The formation of scale and deposits in water distribution systems due to iron contamination can also reduce water flow and increase maintenance costs (Siddique et al., 2021).

Wastewater treatment is a critical process for removing contaminants and pollutants from wastewater to ensure its safe discharge into the environment. The treatment process typically involves physical, chemical, and biological processes to remove contaminants. The first step in the process is the removal of large solids and debris through physical processes such as screening and sedimentation (Bolton, 2017). After this, chemical processes such as coagulation and flocculation are used to remove smaller particles and suspended solids (Wang et al., 2020). Biological treatment processes such as activated sludge or trickling filters are then used to remove organic matter and nutrients from the wastewater (Bolton, 2017). Finally, disinfection processes such as chlorination or ultraviolet irradiation are used to kill any remaining microorganisms in the treated wastewater (Wang et al., 2020). The treated wastewater can then be safely discharged into a nearby water body or reused for non-potable purposes such as irrigation or industrial processes.

The importance of wastewater treatment cannot be overstated as it helps to protect human health and the environment by preventing the spread of disease and reducing pollution in our waterways (World Health Organization, 2018). Untreated wastewater can contain harmful pathogens and pollutants that can have serious health and environmental consequences. Wastewater treatment is therefore essential to safeguard public health and the environment.

Moringa seed oil has been identified as a potential natural and sustainable solution for removing oil and grease from wastewater due to its ability to bind impurities together, forming larger particles that are easily removed (Gomaa et al., 2020; Adeogun et al., 2019). This approach offers an affordable and eco-friendly alternative to conventional wastewater treatment methods and has significant implications for resource conservation and environmental protection (Singh et al., 2017). The use of moringa for wastewater treatment is a promising area of research that warrants further exploration and development, as it has been shown to be effective in treating a variety of wastewater types (Gomaa et al., 2020; Adeogun et al., 2019). By exploring the potential of moringa seed oil for wastewater treatment, we can move towards a more sustainable and efficient approach to managing wastewater.

Activated carbon is a widely recognized and commonly used adsorbent for heavy metal removal from wastewater due to its high surface area, porosity, and chemical stability (Gupta et al., 2014). Activated carbon can be derived from various biomass sources, including agricultural waste, wood, and coconut shells (Girma et al., 2018). Moringa seed husk, an agricultural waste rich in cellulose, lignin, and hemicellulose, has been identified as a potential precursor for the production of activated carbon (Goma et al., 2020; Wang et al., 2020). Previous studies have demonstrated the feasibility of using moringa seed husk for the production of activated carbon and its effectiveness as an adsorbent for the removal of heavy metals from wastewater (Karadi et al., 2006; Wang et al., 2020.) The primary objective of this research is to evaluate the efficacy of utilizing activated carbon sourced from Moringa seed husk as a potential treatment solution for eliminating copper and iron from wastewater. The specific aim is to establish the adsorption capacity of the activated carbon in removing copper and iron ions from the wastewater matrix and to optimize the operating conditions to achieve maximum removal efficiency. The ultimate goal of this research is to present a sustainable and cost-effective treatment method for mitigating heavy metal contamination in wastewater.

## EXPERIMENTATION

For this study, Moringa oleifera seeds were collected from the Agric Road area of Ikot Ekpene Local Government Area in Akwa Ibom State, Nigeria. The seeds were transported to the Chemistry Laboratory of the Department of Science and Technology at Akwa Ibom State Polytechnic, Ikot Osurua, Ikot Ekpene, for further analysis.

A wastewater sample was collected from a soap making factory located in the center of Uyo Akwa Ibom state. The sample was collected in a sterile bottle and transported immediately to the laboratory for analysis and treatment.

The experimental materials used in this study included laboratory equipment, such as a beaker, conical flask, weighing balance, measuring cylinder, filter paper, funnel, heating mantle, retort stand, burette, and mesh sieve. Chemicals used included distilled water, nitric acid, sulfuric acid, zinc chloride, and acetic acid. The Moringa oleifera seeds were ground using a grinder and passed through a mesh sieve before being subjected to oven drying and electrical furnace ashing. The resulting ash was analyzed using an alumina boat and graphite sand. A water bath was also used in the extraction and purification of the active compounds from the seeds.

The concentrations of copper and iron, present in the wastewater before treatment, were determined using an atomic absorption spectrophotometer (AAS) following the method described by Metcalf et al. (1991).

Moringa oleifera pod shells were manually removed and the seeds were washed with tap water and then rinsed with distilled water (Shivani et al., 2008). The seeds were then oven dried for 24 hours, ground in a manual blender, and sieved through a 1mm sieve. To defat the sample, the seed powder was mixed in ethanol and mixed with a magnetic striver for 30-45 minutes. Subsequently, the residue was separated from the supernatant by centrifuging for 10 minutes at 400rpm. The supernatant was decanted and the residual solid was dried at room temperature for 24 hours to obtain the seed cake (Shivani et al., 2008).

Carbonization was performed in a tubular electrical furnace. The impregnated sample was placed in an aluminum boat and inserted into the middle of the furnace with a heating rate of 10°C/min until it turned to activated charcoal. The activated carbon was washed with distilled water until the filtrate reached approximately pH 6. The sample was dried in an oven at a temperature of 90-100°C, allowed to cool, ground into fine particles, and sieved to obtain a particle size of 1mm. The resulting sample was then stored in a desiccator prior to use in the wastewater treatment process (Peavy et al., 1988).

To begin the adsorption process, a retort stand was fixed with a burette and funnel, and a beaker was placed under the burette. Fifteen grams (15g) of activated charcoal were first poured into the burette followed by 20-90g of graphite sand. One hundred milliliters of wastewater was measured in a beaker and poured into the burette filled with activated carbon and graphite sand. However, it underwent the process called chemistry of adsorption before the water was treated (Karadi et al., 2006).

About 100 ml of the sample was measured into a conical flask, and 15 ml of nitric acid was added. The mixture was then heated with a heating mantle at a temperature of 70-90°C until the solution appeared colorless and reduced to 25 ml. The flask was allowed to cool sufficiently to avoid splattering before filtering with a filter paper. The filtrate was stored for the determination of heavy metals (Metcalf et al., 1991).

For the determination of heavy metals, a stock solution containing 100 mg/ml Cu was prepared by dissolving 2.682 g of $CuCl2·H2O$ in de-ionized water and finally diluted to 100 ml. Standard solutions of concentrations 0.0, 0.5, 1.0, and 2.0 ppm were prepared from this stock solution (Girma et al., 2018).

Iron: A stock solution containing 1000 mg/mg of Fe was prepared from 1.0 g of pure iron wire. The wire was dissolved in 100 ml concentrated HNO3, boiled on a water bath, and diluted to 100 ml with distilled water. From this stock solution, a standard solution was prepared. The concentrations of copper and iron, present in the wastewater after treatment, were determined using an atomic absorption spectrophotometer (AAS) following the method described by Metcalf et al. (1991).

**OBSERVATIONS FROM THE EXPERIMENTS CARRIED OUT**

The concentration of heavy metals prior to treatment, the concentration of heavy metals following treatment, and the WHO acceptable limit are all shown in Table 1.

**Table 1: Comparison of sample concentration pre- and post-treatment**

| **Heavy metal** | **Concentration before treatment** | **Concentration after treatment** | **WHO permissible limit** |
|---|---|---|---|
| Copper(Cu) | 20.10 + 0.039 | 0.99 + 0.009 | 0.00 ≤ 2.00 |
| Iron (Fe) | 15.61 + 0.055 | 1.23+ 0.005 | 0.00 ≤ 3.00 |

Table 1 shows that following treatment, iron (Fe) and copper (Cu) readings dramatically fell from (15.61 + 0.055) mg/L to (1.23 + 0.005) mg/L and (20.10 + 0.039) mg/L to (0.99 + 0.009) mg/L, respectively, which is within the WHO permitted limit. However, the pH conductivity did not noticeably change. Overall, 15g of biochar generated from moringa seed husk was successful in removing Cu and Fe heavy metals.

This outcome is in line with earlier research by Siddhuraju and Becker (2003) and Meneghel et al. (2013) that showed activated carbon's effectiveness in removing heavy metals from wastewater.

## CONCLUSION

Excessive levels of copper and iron in water can pose various health risks such as nausea, vomiting, diarrhea, gastric complaints, and headaches in the short term, and liver or brain damage over the long term. However, the concentration of copper and iron after treatment in this study was within the permissible limits, indicating that the water is safe for consumption. Moreover, the use of natural adsorbents, such as Moringa oleifera seed cake, was investigated by Ndibewu et al. (2011) as an alternative method for heavy metal removal in wastewater treatment. The study revealed that the activated carbon process from Moringa seed cake demonstrated high efficiency in removing heavy metals from wastewater samples. Therefore, the use of natural adsorbents may present a promising alternative to traditional wastewater treatment methods for heavy metal removal.

## RECOMMENDATION

Based on the findings of this study, we recommend the use of Moringa oleifera seed cake as a natural adsorbent for the removal of heavy metals from wastewater. The activated carbon process from Moringa seed cake was found to be highly effective in removing heavy metals such as copper and iron from wastewater samples. This could offer a sustainable, appropriate, effective, and robust water treatment means, particularly in developing countries where access to conventional water treatment methods may be limited.

Moreover, we recommend further studies to investigate the effectiveness of Moringa oleifera seed cake as a natural adsorbent for other heavy metals and pollutants in wastewater. Additionally, more research is needed to optimize the conditions for the activated carbon process from Moringa seed cake and to evaluate its economic feasibility for large-scale application. Overall, the findings of this study suggest that the use of Moringa oleifera seed cake as a natural adsorbent holds great potential for the development of sustainable and effective wastewater treatment technologies.

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